Historic Structures

significant structures of the past

John A. Roebling's Niagara River Railroad Suspension Bridge – 1855

By Frank Griggs, Jr., Dist. M.ASCE, D.Eng., P.E., P.L.S.

Dr. Griggs specializes in the restoration of historic bridges, having restored many 19th Century cast and wrought iron bridges. He was formerly Director of Historic Bridge Programs for Clough, Harbour & Associates LLP in Albany, NY, and is now an independent Consulting Engineer. Dr. Griggs can be reached at ***fgriggsjr@verizon.net****.*

The Niagara River gorge had long separated the United States from Canada. It varied in depth up to 239 feet and in width generally between 800 and 1000 feet between the Falls and Lewiston. In 1845, Charles B. Stuart, then working on the location of the Great Western Railway in Canada, was looking for a way to connect his line with the Rochester and Niagara Falls branch of the New York Central. He proposed to span the gorge with a suspension bridge just above the Whirlpool. Many thought his idea foolhardy as the only suspension bridges in the United States, other than some Finley bridges left over from the early part of the century, were Charles Ellet's Fairmount Bridge over the Schuylkill River built in 1842 and John A. Roebling's suspension aqueduct built across the Allegheny River in 1845. The English had given up on the use of suspension bridges for railways after Captain Samuel Brown's attempt failed on the Stockton and Darlington Railway in the 1820s.

Stuart, however, did not share this belief and decided to send a circular letter to "a number of the leading Engineers of America and Europe, asking their opinion of the undertaking." Of those who responded, only four thought the project feasible. Stuart wrote, "Charles Ellet, Jr., John A. Roebling, Samuel Keefer and Edward Serrell, alone favored the project..." Ellet's response stated in part:

> *In the case which you have presented, I can, however, say this much with all confidence: A bridge may be built across the Niagara below the Falls, which will be entirely secure, and in all respects fitted for railroad uses. It will be safe for the passage of locomotive engines and freight trains, and adapted to any purpose for which it is likely to be applied...To build a bridge at Niagara has long been a favorite scheme of mine. Some twelve years ago I went to inspect the location, with a view to satisfy myself of its practicability, and I have never lost sight of the project since. I do not know in the whole circle of profession schemes a single project which it would gratify me so much to conduct to completion.*

Roebling responded:

> *I have bestowed some time upon this subject since the receipt of your letter, and have matured plans and working details. Although the question of applying the principle of suspension to railroad bridges has been disposed of in the negative by Mr. Robert Stephenson, when discussing the plan of the Britannia Bridge over the Menai, on the Chester and Holyhead Railway, I am bold enough to say that the celebrated Engineer has not at all succeeded in the solution of this problem. That a suspension bridge can be built to answer for a railroad, is proven by the Monongahela Bridge...The greater the weight to be supported, the stronger the cables must be, and as this is a matter of unerring calculation, there need be no difficulty on the score of strength. The only question which presents itself is: can a suspension bridge be made stiff enough, as not to yield and bend under the weight of a railroad train when unequally distributed over it; and can the great vibration which result from the rapid motion of such trains, and which prove so destructive to common bridges, be avoided and counteracted?...I answer this in the affirmative, and maintain that wire cable bridges, properly constructed, will be found hereafter the most durable and cheapest railroad bridge for spans over one hundred feet...*

Roebling's Bridge 1855 to 1897, under deck wind cables not shown.

In 1846, based on these responses, a charter was given to the Niagara Bridge Company by the State of New York and by the Provincial Parliament. By 1847, sufficient funds had been raised to retain an engineer and start construction. In February 1847, Ellet submitted a proposal stating:

> *Immediately after inspecting the site, in eighteen hundred and forty-five, I gave the whole subject a careful investigation, and made a fair, but not extravagant, estimate of the cost of such a structure as I thought would be appropriate and of adequate strength.*
>
> *This estimate amounted to two hundred and twenty thousand dollars for a railroad bridge competent to sustain the weight of locomotive engines and heavy freight trains, and one hundred and ninety thousand dollars for one suitable for common travel, with a railroad track in the centre, to be crossed by passenger and burthen cars drawn by horses.*
>
> *When I made my estimate, I had in view a work of the first order, and as I do not wish to be in any way connected with one of a lower grade, I cannot offer to reduce my proposition. But I will now repeat, that a secure, substantial and beautiful edifice, not one however, equal to the claim of the locality – for nothing can match that – but a noble work of art, which will form a safe and sufficient connection between the great Canadian and the New York railways, and stand firm for ages, may be erected over the Niagara river for the latter sum named…*

Ellet's (STRUCTURE, October 2006) proposal was accepted over Roebling's, with modifications, on November 9th for the sum of $190,000. The span was to be 800 feet with a deck width of 28 feet. The deck would have two carriageways, two footways, and one railway track in the center of the floor. Ellet started by building a nine-foot wide suspension pedestrian and carriageway over the gorge to service the construction of the permanent bridge. There are several great stories concerning Ellet in the construction of this bridge. One has to do with him offering anyone five dollars if they could fly a kite over the gorge and have it land on the other side so he could use the kite line to pull larger strings and ropes successively across the gorge. Another has to do with his first ride across the gorge in an iron basket shortly after he had succeeded in pulling a wire cable across. The last story has him riding his horse across the temporary bridge, before he had attached the railing, at a break-neck speed.

Later in the year, however, he had a disagreement with the directors "respecting the application of tolls taken on the footbridge, which after some litigation, ended by a compromise, by which Ellet relinquished his contract; and his work terminated on the twenty-seventh of December, eighteen hundred and forty-eight." Ellet then returned to Wheeling to finish his 1,010-foot suspension bridge (STRUCTURE, May 2016)

John Roebling (STRUCTURE, November 2006) would not take over the project until 1850. In 1847 and 1848, he, for the earlier competition, had worked out designs for a bridge all on one level and one with a double deck that located a single track railroad on the upper level and a roadway on a lower deck. He offered to build the double deck bridge for $180,000 and to subscribe to $20,000 in stock in the bridge company.

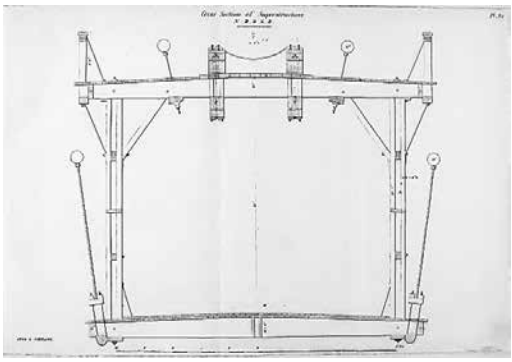
While all this was going on, Edward W. Serrell (STRUCTURE, February 2012) spanned the gorge with a suspension bridge 1,043 feet long connecting Lewiston, New York, and Queenstown, Ontario, in 1851. In 1864, Serrell removed his below deck wind cables during an ice jam and the bridge would eventually blow down. He had not yet replaced the wind cables when a windstorm came up contributing to the failure. The fourth engineer who answered Stuart, Samuel Keefer, would also build a 1,268-foot span suspension bridge across the gorge at the Falls, but that would not be until 1869.

Roebling started work on the Niagara project in 1852. He provided all engineering services including design as well as construction supervision. The wire for his cables, one million pounds worth, came from England, but his company supplied a significant amount of the wire used on the bridge in the under and above deck stays. He completed his 821-foot 6-inch span double-deck bridge in 1855. The one-track railroad ran on the upper deck, and carriages and other vehicles passed on the lower deck.

He had a total of 64 stay cables of 1⅜-inch diameter, a total of 624 suspenders spaced 5 feet apart, four main cables 10 inches in diameter with 3,640 no. 9 gauge wires each and 56 under deck cables (river stays) anchored to the bedrock on the banks of the river. He did not carry his stays over the top of towers and down to the anchorage but tied them directly to the cast iron roller plate at the top of the towers. The four masonry towers were 15 feet square at the base and 8 feet square at the top, with a height of 60 feet 6 inches. The length, center to center of towers, was 821 feet 6 inches with a deck length of 800 feet. His stiffening trusses on each side were 18 feet deep, and were spaced 24 feet apart at the lower level and 25 feet apart on the upper level. The diagonals were wrought iron rods 1-inch in diameter at an angle of 45° and crossed four doubled wooden verticals spaced at 5 feet.

In his final report to the Board, which was very complete, he also discussed Ellet's earlier bridge across the Niagara and the cause of the failure of Ellet's Bridge at Wheeling in 1854. Roebling proudly stated,

> *One single observation of the passage of a train over the Niagara Bridge will convince the most skeptical that the practicality of suspended railway bridges, so much doubted heretofore, has been successfully demonstrated... Bridges of half a mile, for common or Railway travel, may be built, using iron for the cables, with entire safety. But by substituting the best quality of steel wire, we may nearly double the span, and afford the same degree of security… As regards the success of your work, more has been accomplished than was promised… It is a great satisfaction to me, that this work has turned out equal to my promise, and also to know, that on taking leave of you, the mutual confidence that exists, will not undergo any change.*



Section of double deck bridge.

Towers, approach to the lower deck, cables, and side trusses.

Roebling described the bridge in his *Final Report to the Presidents and Directors of the Niagara Falls Suspension and Niagara Falls International Bridge Companies* dated May 1, 1855. It was also published in *Papers and Practical Illustrations of Public Works of Recent Construction both British and American* by John Weale in London in 1856. Roebling was wrong about suspension bridges being the best choice for railroad bridges with spans over 100 feet. Time proved that long span simple trusses, cantilever trusses, and continuous trusses were the most efficient for railroad purposes.

After traveling across the bridge, Mark Twain commented,

> *Then you drive over to Suspension Bridge and divide your misery between the chances of smashing down two-hundred feet into the river below, and the chances of having a railway-train overhead smashing down onto you. Either possibility is discomforting taken by itself, but, mixed together, they amount in the aggregate to positive unhappiness.*

Over the years, Leffert L. Buck (STRUCTURE, December 2010) replaced some rusted wires at the anchorages, replaced the side trusses with iron, strengthened the anchorages and replaced the stone towers with iron, all without stopping traffic on the bridge. In 1897, he built a double deck braced spandrel steel arch bridge, under and around Roebling's bridge, carrying two tracks on the upper level and transferring the load to the new bridge, also without stopping traffic.▪